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1st Draft (Garvin/McKay)

Basic *Lunar Dust Science* Splinter

Overarching Question: What are the key science questions associated with the lunar dust environment?

<u>Outline of Discussion Topics</u>

<u>BASIC DUST CHARACTERIZATION</u>

Lunar Dust as studied from Apollo/Luna Samples:

1. Dust collection as "samples" and state of the collection at JSC
2. Dust particle size distribution (PSD) statistics and implications
3. Dust geochemistry (and provenance), including volatiles
4. Dust shapes and related mechanical properties
5. Electrical properties of dust (measured) & Magnetic ones
6. Relevant experiments on lunar dust (ongoing vs completed)
7. Possible gaps in basic characterization of Apollo dust samples
8. Dust dynamics on the Moon
   a. Typical migration/generation pathways
   b. Effects of impacts given knowledge of flux
   c. Effects of space weathering on dust particle shapes and PSDs
   d. Geochemical implications of dust dynamics and generation
   e. Dust effects associated with downslope movements
   f. Magnetic effects

Perceived gaps in science knowledge about lunar dust:

1. What we <u>cannot</u> learn from existing lunar dust sample archive
2. What we <u>can</u> learn from the Apollo dust collection
3. What we <u>might</u> learn from orbital remote sensing (LRO, etc.)
4. Do we need robotic Dust Sample Return before human return?
5. Life sciences experiments using lunar dust as basic science
6. What aspects of lunar dust science can wait till human return?
7. What basic lunar dust science must be done in situ via LPRP?
8. Are there simple observations we can do now, or using the planned US missions such as LRO, LCROSS, etc. (extended missions?)

Recommendations for gap-filling in a time-ordered, prioritized program:

1. From now (2007) thru early 2009 (pre-LRO, LCROSS, Chandrayaan)
2. New Apollo dust sample experiments to be considered
3. Apollo dust digital archive (*Sourcebook II*, ala W. Mendell)
4. What orbital remote sensing COULD contribute (if anything)

5. Highest priority landed experiments in the 2010-2013 era (for dust)
6. Next generation dust characterization and analysis for beyond 2013
7. Dust science experiments that can wait till human return

Traceability of lunar dust science requirements to Exploration needs/goals/objectives:

Lunar Dust science information and measurements that:

1. Impact general human sustainability on the lunar surface
2. Impact life support beyond “sortie” class missions (3-7 days)
3. Impact flight systems that sustain humans (power, telecom, EVA)
4. Relate to hazards, including space weather (CME’s and SPE’s)
5. Impact designs of optimized spacesuits for EVA
6. Impact science-driven sample collection and analysis on the Moon
7. Impact science priorities related to astrophysics
8. Prepare for human exploration of Mars (and martian dust issues)
9. Could impact mobility (of humans) via rovers, hoppers, etc.
10. Civil engineering of sustainable habitats
11. Future fission-based power delivery systems
12. Timely engineering design decisions for LSAM etc.

Life sciences and Astrobiology science priorities and lunar dust

1. What matters if the Moon is to be a “test-bed”
2. Do we have adequate materials (dust at JSC) on hand?
3. What are the first steps, if any?
    a. Experiments using existing dust samples
    b. Experiments using new dust samples (polar?)
    c. “Leave-behind” experiments at Outpost site(s)?

ISSUES TO DISCUSS:

1. Is polar regolith and dust fraction different from Equatorial mare/highlands?
2. How do we know how complete our knowledge of dust is at present?
3. Minimum set of activities to prioritize for next 2-3 years (on dust samples)
4. New approaches to employ on dust characterization
    a. Nano-phase characterization methods
    b. In situ robotic methods (pre-human): SEM? Other…
    c. Subsurface dust?
    d. Dust impact experiments at lunar “g”?
5. How variable could the lunar dust PSD’s be (spatially, at depth, etc.)
6. What “dust as science” goals are top priorities as we return to the Moon?

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Lunar dust issues in suit and module designs for discussions

1. Methods to prevent dust from entering habitat modules
2. Suit cleaning & maintenance
3. Protection of seals, quick disconnects, hose connectors
4. Protection and cleaning of optical components:
    a. Radiators
    b. Visors
    c. Lights
    d. Displays
    e. Photovoltaic arrays
    f. Windows
    g. Peel-off optical coatings
5. Technology to detect and measure dust levels in the atmosphere
6. Dust deposition on surfaces and in materials
7. Electrostatic/magnetic interaction with electrical systems
8. Personal hygiene dust removal
9. Effects of dust on components & suit thermal properties
10.

Need to know or receive:

From Medical:

1. dust levels with for human exposure time limits

From Dust basic research community

1. Dust Particle Size distribution
    a. Air borne in lunar gravity with time profile for different size ranges
    b. Non-air borne in lunar gravity
2. Adhesive properties
3. Abrasive properties
4. Magnetic & Electrostatic properties
5. Reactive phase
    a. Materials & atmospheric
    b. Time to react to an Atmosphere with oxygen and humidity
    c. Human interaction
    d.
6. Flammability/dust flash fire risk
7. Dust Simulants for testing
    a. Identify lunar dust characteristics
    b. Create simulants to mimic the different characteristics

Mapping into suggested format:

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Dust Science issues organized as::

- Observations
- Recommendations
- Findings
- Alternative views

Recommended research tasks roughly prioritized as:

- Crew life critical
- Mission critical
- Important short term information
- Important long term information

<u>Basic Science Splinter Group *Preliminary* Agenda:</u>

Day 1: **Topic**	**Presenter**	**Duration**
Introduction/Objectives/Process	J. Garvin/C. McKay	15 min
Briefing: Overview dust science issues	D. McKay and other	15 min
Briefing: Life science dust issues	T. Ricco, R. Kerschmann	15 Min
Discussion:	All	60 min
Break		15 min
Discussion: How much more and do we need to know about lunar dust to enable human exploration 1) short term (<14 days) and 2) long term (>14 days)	All	60 min
Summary: Day 1 key findings and recommendations	J. Garvin/C. McKay	30 min
Day 2:		
Introduction/Summary recap of Day 1	J. Garvin/C. McKay	15 min
Discussion: Prioritization of research	All	90 min
Break		15 min
Discussion: Types of measurements and research activities necessary to accomplish priority objectives	All	90 min
Summary: Day 2 key findings and recommendations	J. Garvin/C. McKay	30 min
Day 3:		
Introduction/Summary recap of Day 2	J. Garvin/C. McKay	15 min
Discussion: Continue discussion on groupings and priorities, format reply to NESC format.	All	120 min
Final Summary: Key findings and recommendations	J. Garvin/C. McKay	60 min